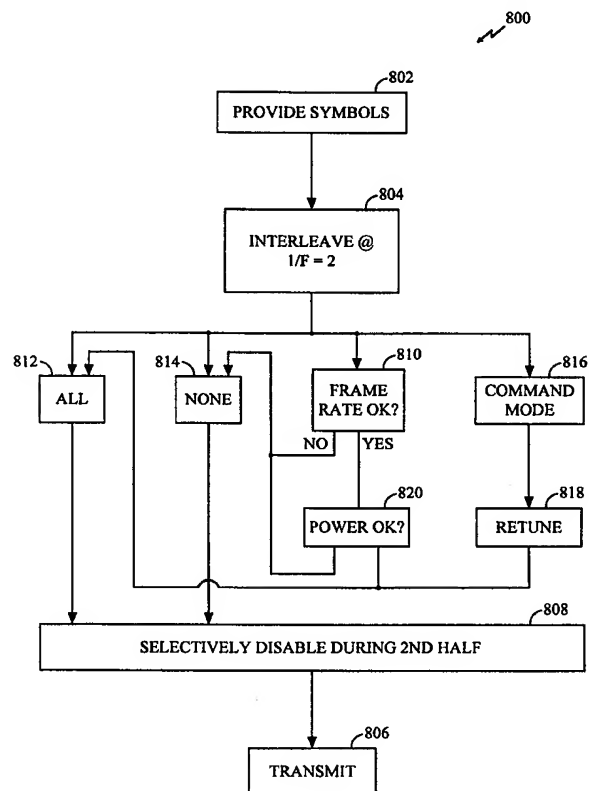# PCT

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(54) Title: METHOD AND SYSTEM FOR TRANSMIT GATING IN A WIRELESS COMMUNICATION SYSTEM

(57) Abstract

A method and system for communicating a frame of information according to both a continuous transmit format and a discontinuous transmit format. The present invention contemplates transmitting one or more data rates in either a continuous transmit mode (814) or a discontinuous transmit mode (812). The present invention contemplates continuous tranmissions only for certain data rates, and selection between continuous and discontinuous transmission for other data rates (810). Frames transmitted in the discontinuous transmit mode may be transmitted at a higher transmit power than in the continuous transmit mode (820). In one embodiment, the information is transmitted at a fifty–percent duty cycle during the second half of the frame when in the discontinuous transmit mode (808). During periods of non–transmission, an alternative system may be searched for as a possible candidate for hard handoff (816).

# METHOD AND SYSTEM FOR TRANSMIT GATING IN A WIRELESS COMMUNICATION SYSTEM

## BACKGROUND OF THE INVENTION

### Cross-reference to Provisional Application

This application claims the benefit of United States provisional application number 60/075,211, filed on February 19, 1998. The disclosure of this provisional application is incorporated herein by reference.

### I. Field of the Invention

The present invention relates to communications. More particularly, the present invention relates to a novel and improved method and apparatus for transmitting variable rate data in a wireless communication system, and for assisting a hard handoff.

### II. Description of the Related Art

The use of code division multiple access (CDMA) modulation techniques is one of several techniques for facilitating communications in which a large number of system users are present. Other multiple access communication system techniques, such as time division multiple access (TDMA) and frequency division multiple access (FDMA) are known in the art. However, the spread spectrum modulation techniques of CDMA have significant advantages over these modulation techniques for multiple access communication systems. The use of CDMA techniques in a multiple access communication system is disclosed in U.S. Patent No. 4,901,307, entitled "SPREAD SPECTRUM MULTIPLE ACCESS COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS", assigned to the assignee of the present invention, and incorporated by reference herein. The use of CDMA techniques in a multiple access communication system is further disclosed in U.S. Patent No. 5,103,459, entitled "SYSTEM AND METHOD FOR GENERATING SIGNAL WAVEFORMS IN A CDMA CELLULAR TELEPHONE SYSTEM", assigned to the assignee of the present invention and incorporated by reference herein.

CDMA by its inherent nature of being a wideband signal offers a form of frequency diversity by spreading the signal energy over a wide bandwidth.

Therefore, frequency selective fading affects only a small part of the CDMA signal bandwidth. Space or path diversity is obtained by providing multiple signal paths through simultaneous links from a mobile user through two or more cell-sites. Furthermore, path diversity may be obtained by exploiting the multipath environment through spread spectrum processing by allowing a signal arriving with different propagation delays to be received and processed separately. Examples of path diversity are illustrated in U.S. Patent No. 5,101,501 entitled "METHOD AND SYSTEM FOR PROVIDING A SOFT HANDOFF IN COMMUNICATIONS IN A CDMA CELLULAR TELEPHONE SYSTEM", and U.S. Patent No. 5,109,390 entitled "DIVERSITY RECEIVER IN A CDMA CELLULAR TELEPHONE SYSTEM", both assigned to the assignee of the present invention and incorporated by reference herein.

A method for transmission of speech in digital communication systems that offers particular advantages in increasing capacity while maintaining high quality of perceived speech is by the use of variable rate speech encoding. The method and apparatus of a particularly useful variable rate speech encoder is described in detail in U.S. Patent No. 5,414,796, entitled "VARIABLE RATE VOCODER", assigned to the assignee of the present invention and incorporated by reference herein.

The use of a variable rate speech encoder provides for data frames of maximum speech data capacity when the speech encoder is providing speech data at a maximum rate. When the variable rate speech encoder is providing speech data at a less that maximum rate, there is excess capacity in the transmission frames. A method for transmitting additional data in transmission frames of a fixed predetermined size, wherein the source of the data for the data frames is providing the data at a variable rate, is described in detail in U.S. Patent No. 5,504,773, entitled "METHOD AND APPARATUS FOR THE FORMATTING OF DATA FOR TRANSMISSION", assigned to the assignee of the present invention and incorporated by reference herein. In the above mentioned patent application a method and apparatus is disclosed for combining data of differing types from different sources in a data frame for transmission.

In frames containing less data than a predetermined capacity, power consumption may be lessened by transmission gating a transmission amplifier such that only parts of the frame containing data are transmitted. Furthermore, message collisions in a communication system may be

reduced if the data is placed into frames in accordance with a predetermined pseudorandom process. A method and apparatus for gating the transmission and for positioning the data in the frames is disclosed in U.S. Patent No. 5,659,569, entitled "DATA BURST RANDOMIZER", assigned to the assignee of the present invention and incorporated by reference herein.

A useful method of power control of a mobile in a communication system is to monitor the power of the received signal from the wireless communication device at a base station. In response to the monitored power level, the base station transmits power control bits to the wireless communication device at regular intervals. A method and apparatus for controlling transmission power in this fashion is disclosed in U.S. Patent No. 5,056,109, entitled "METHOD AND APPARATUS FOR CONTROLLING TRANSMISSION POWER IN A CDMA CELLULAR MOBILE TELEPHONE SYSTEM", assigned to the assignee of the present invention and incorporated by reference herein.

In a communication system that provides data using a QPSK modulation format, very useful information can be obtained by taking the cross product of the I and Q components of the QPSK signal. By knowing the relative phases of the two components, one can determine roughly the velocity of the wireless communication device in relation to the base station. A description of a circuit for determining the cross product of the I and Q components in a QPSK modulation communication system is disclosed in U.S. Patent No. 5,506,865, entitled "PILOT CARRIER DOT PRODUCT CIRCUIT", assigned to the assignee of the present invention and incorporated by reference herein.

There has been an increasing demand for wireless communications systems to be able to transmit digital information at high rates. One method for sending high rate digital data from a wireless communication device to a central base station is to allow the wireless communication device to send the data using spread spectrum techniques of CDMA. One method that is proposed is to allow the wireless communication device to transmit its information using a small set of orthogonal channels. Such a method is described in detail in co-pending U.S. Patent Application Serial No. 08/886,604, entitled "HIGH DATA RATE CDMA WIRELESS COMMUNICATION SYSTEM", assigned to the assignee of the present invention and incorporated by reference herein.

In the just-mentioned application, a system is disclosed in which a pilot signal is transmitted on the reverse link (the link from the wireless communication device to the base station) to enable coherent demodulation of the reverse link signal at the base station. Using the pilot signal data,
5   coherent processing can be performed at the base station by determining and removing the phase offset of the reverse link signal. Also, the pilot data can be used to optimally weigh multipath signals received with different time delays before being combined in a rake receiver. Once the phase offset is removed, and the multipath signals properly weighted, the multipath
10  signals can be combined to decrease the power at which the reverse link signal must be received for proper processing. This decrease in the required receive power allows greater transmission rates to be processed successfully, or conversely, the interference between a set of reverse link signals to be decreased.

15      While some additional transmit power is necessary for the transmission of the pilot signal, in the context of higher transmission rates the ratio of pilot signal power to the total reverse link signal power is substantially lower than that associated with lower data rate digital voice data transmission cellular systems. Thus, within a high data rate CDMA
20  system, the $E_b/N_0$ gains achieved by the use of a coherent reverse link outweigh the additional power necessary to transmit pilot data from each wireless communication device.

An additional benefit of the reverse link described in this co-pending application is that it generates less amplitude modulation (AM) interference
25  due to its continuous-transmit nature. Thus, users with sensitive electronic equipment such as hearing aids and pacemakers will experience less interference than with a discontinuous transmit reverse link. Another example of the use of continuous transmission to reduce AM interference is given in co-pending U.S. Patent Application Serial No. 08/639,572, filed
30  April 29, 1996, entitled "SYSTEM AND METHOD FOR REDUCING INTERFERENCE GENERATED BY A CDMA COMMUNICATIONS DEVICE", assigned to the assignee of the present invention and incorporated herein by reference.

However, when the data rate is relatively low, a continuously-
35  transmitted pilot signal on the reverse link contains more energy relative to the data signal. At these low rates, the benefits of coherent demodulation and reduced interference provided by a continuously-transmitted reverse

link pilot signal may be outweighed by the decrease in talk time and system capacity in some applications. A method and system is needed provides flexibility in reverse link transmission format as needed to optimize these tradeoffs.

Further, a communications device may need to go into hard handoff from a first system to a second system. If discontinuous transmission is possible, the device may search for the second system during the periods of non-transmission, while maintaining contact with the first system during periods of transmission.

## SUMMARY OF THE INVENTION

The present invention is a novel and improved method and system for communicating a frame of information according to both a continuous transmit format and a discontinuous transmit format. In one aspect of the present invention, a method is disclosed for transmitting frames of information. The method includes transmitting information continuously throughout the frame when in a continuous transmit mode and the frame is of a first data rate of a plurality of data rates; and transmitting the information discontinuously in the frame when in a discontinuous transmit mode and the frame is of the first data rate. Thus, the present invention contemplates transmitting one or more data rates in either a continuous transmit mode or a discontinuous transmit mode.

The method may further include transmitting the information continuously throughout the frame when the frame is of a second data rate of the plurality of data rates. Thus, the present invention contemplates continuous transmission only for certain data rates, and selection between continuous and discontinuous transmission for other data rates.

In one embodiment of the present invention, the first data rate corresponds to a first transmit power and the second data rate corresponds to a second transmit power, and the first transmit power is less than the second transmit power. In this embodiment, the method includes transmitting the frame of the first data rate at the second transmit power when in the discontinuous transmit mode. Thus, frames transmitted in the discontinuous transmit mode may be transmitted at a higher transmit power than in the continuous transmit mode.

In one embodiment of the present invention, the information is transmitted at a fifty-percent duty cycle during the frame when in the discontinuous transmit mode. This may include transmitting the information during a second half of the frame.

Another embodiment of the present invention includes selecting between the continuous transmit mode and the discontinuous transmit mode in response to a transmit power of the wireless communication device. In other words, the present invention may include selecting the discontinuous transmit mode when the transmit power is less than a predetermined threshold. In an alternate embodiment, the present invention includes selecting between the continuous transmit mode and the discontinuous transmit mode according to a user-defined preference.

The present invention also contemplates a wireless communication device for transmitting frames of information. The wireless communication device includes a variable rate data source for generating the frames of information, each of the frames of information having one of a plurality of data rates. It also includes a transmitter for transmitting the information continuously throughout the frame when in a continuous transmit mode and when the frame is of a first data rate of the plurality of data rates, and for transmitting the information discontinuously in the frame when in a discontinuous transmit mode and when the frame is of the first data rate. Thus, the wireless communication device may transmit frames of a given data rate either continuously or discontinuously. A control processor selects between the continuous transmit mode and the discontinuous transmit mode. The wireless communication device may implement the method of the present invention as summarized briefly above.

The present invention also includes a method for receiving a frame of information in a wireless receiver, wherein the information may be continuously present throughout the frame or discontinuously present in the frame. This method includes filtering the frame of information in a sliding window filter to produce a sliding window phase estimate signal, filtering the frame of information in a block window filter to produce a block window phase estimate signal, and selecting between the sliding window phase estimate signal and the block window phase estimate signal in response to whether the information is continuously present in the frame.

In one embodiment of the present invention, the method includes selecting the sliding window phase estimate signal when the information is continuously present in the frame, and selecting the block window phase estimate signal when the information is discontinuously present in the frame. Additionally, the method may include selecting the block window phase estimate signal before and after a phase discontinuity in the frame.

The present invention further contemplates a wireless receiver for receiving a frame of information wherein the information may be continuously present throughout the frame or discontinuously present in the frame. The wireless receiver includes a sliding window phase estimator for filtering the frame of information in a sliding window to produce a sliding window phase estimate signal, a block window phase estimator for filtering the frame of information in a block window to produce a block window phase estimate signal, and a multiplexer for selecting between the sliding window phase estimate signal and the block window phase estimate signal in response to whether the information is continuously present in the frame. The wireless receiver may implement the method briefly described above.

Additionally, the present invention discloses a method, in a wireless communication system, for communicating a frame of information between a wireless communication device and a wireless base station in a continuous transmit mode and a discontinuous transmit mode. The method includes transmitting, from the wireless communication device, the information continuously throughout the frame when in the continuous transmit mode, and transmitting, from the wireless communication device, a first message notifying the wireless base station of an intention to transmit in a discontinuous mode. In response, the base station transmits a second message acknowledging the intention to transmit in the discontinuous mode, and the wireless communication device transmits the information discontinuously in the frame when in the discontinuous transmit mode, and in response to the second message.

In one embodiment, the method further includes demodulating the frame of information according to a continuous transmit format when the information is continuously present throughout the frame, and demodulating, the frame of information according to a discontinuous transmit format when the information is discontinuously present in the frame.

The present invention further contemplates a wireless communication system for communicating a frame of information in a continuous transmit mode and a discontinuous transmit mode. The wireless communication system includes a wireless communication device and a wireless base station that implement the method described briefly above.

In a final aspect of the present invention, a method and apparatus are disclosed for facilitating hard handoff from a first system to a second system. The device searches for the second system during the periods of non-transmission, while maintaining contact with the first system during periods of transmission.

Gating is supported for rate sets 3, 4, 5 and 6. When a frame is gated, only the symbols within the second half of the frame are sent. This means that symbols 6144 through 12287, numbering from 0, are transmitted. During gating, the maximum frame rate is rate 1/2.

Normally, the blocks are transmitted using continuous transmission, with the exception of the rate 1/8 frame which is gated. The continuous transmission reduces the interference in the audio band. The rate 1/8 frame is gated because it improves the reverse link capacity and the mobile station talk time relative to when continuous transmission is used.

However, rate set 3, 4, 5 and 6 may be commanded into a mode where only rate 1/8, rate 1/4, and rate 1/2 frames are transmitted and are transmitted using gated transmission. This mode is used to allow the mobile station time to retune its receiver and search for systems using frequencies and other technologies (e.g. AMPS and GSM).

During gating, the second half of the frame is transmitted for the following reasons. First, the gating needs to be either in the first half or the second half of the frame. If it were not, then the frame would not contain a contiguous 10 milliseconds for searching. Second, the transmitted portion of the frame needs to occur later in the frame in order to allow the mobile station time to estimate the difference between the measured and expected forward signal to noise ratio. Therefore, during gating, the second half of the frame is sent.

In addition, rate set 3, 4, 5 and 6 may be commanded into a mode where all frames are transmitted using continuous transmission. This mode is used by mobile stations that may need to further reduce audio band interference.

A mobile station commanded into gated mode for searching will be commanded to periodically gate $N$ frames out of $M$ frames on the forward link and reverse link simultaneously, starting at system time $T$. The values of $N$ and $M$ depend on the technology being searched and the number of
5   channels being searched.

## BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will
10   become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

FIG. 1 is a functional block diagram of an exemplary embodiment of the transmission system of the present invention embodied in wireless
15   communication device **50**;

FIG. 2 is a functional block diagram of an exemplary embodiment of modulator **26** of FIG. 1;

FIG. 3 illustrates four graphs of the average energy transmitted by transmitter **28** of FIG. 1 over a single frame for four different data rates;
20   FIG. 4 is a functional block diagram of selected portions of a base station **400** in accordance with the present invention;

FIG. 5 is an expanded functional block diagram of an exemplary single demodulation chain of demodulator **404** of FIG. 4; and

FIG. 6 is an expanded functional block diagram of an exemplary pilot
25   filter that uses a sliding window estimator in combination with a block window estimator.

FIG. 7 is a block diagram of apparatus for assisting in hard handoff.

FIG. 8 is a block diagram of a method for assisting in hard handoff.

30         **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

FIG. 1 illustrates a functional block diagram of an exemplary embodiment of the transmission system of the present invention embodied
35   in wireless communication device **50**. It will be understood by one skilled in the art that the methods described herein could be applied to transmission from a central base station (not shown) as well. It will also be

understood that various of the functional blocks shown in FIG. 1 may not be present in other embodiments of the present invention. The functional block diagram of FIG. 1 corresponds to an embodiment that is useful for operation according to the TIA/EIA Standard IS-95C, also referred to

5 commercially as cdma2000. Other embodiments of the present invention are useful for other standards including Wideband CDMA standards and dual-mode CDMA/GSM standards. These other embodiments differ somewhat in the formatting of data for transmission, but still include the inventive principles described herein.

10     In the exemplary embodiment of FIG. 1, the wireless communication device transmits a plurality of distinct channels of information which are distinguished from one another by short orthogonal spreading sequences as described in the aforementioned U.S. Patent Application Serial No. 08/886,604. Five separate code channels are transmitted by the wireless

15 communication device: 1) a first supplemental data channel 38, 2) a time multiplexed channel of pilot and power control symbols 40, 3) a dedicated control channel 42, 4) a second supplemental data channel 44 and 5) a fundamental channel 46. The first supplemental data channel 38 and second supplemental data channel 44 carry digital data which exceeds the

20 capacity of the fundamental channel 46 such as facsimile, multimedia applications, video, electronic mail messages or other forms of digital data. The multiplexed channel of pilot and power control symbols 40 carries pilots symbols to allow for coherent demodulation of the data channels by the central base station and power control bits to control the energy of

25 transmissions to wireless communication device 50. Control channel 42 carries control information to the central base station such as modes of operation of wireless communication device 50, capabilities of wireless communication device 50 and other necessary signaling information. Fundamental channel 46 is the primary channel used to carry the primary

30 information signal from the wireless communication device to the central base station. In the case of speech transmissions, the fundamental channel 46 carries the speech data.

     Supplemental data channels 38 and 44 are encoded and processed for transmission by means not shown and provided to modulator 26. Power

35 control bits are provided to repetition generator 22 which provides repetition of the power control bits before providing the bits to multiplexer

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(MUX) 24. In multiplexer 24 the redundant power control bits are time multiplexed with pilot symbols and provided on line 40 to modulator 26.

Message generator 12 generates necessary control information messages and provides the control message to CRC and tail bit generator 14.

5    CRC and tail bit generator 14 appends a set of cyclic redundancy check bits which are parity bits used to check the accuracy of the decoding at the central base station and appends a predetermined set of tail bits to the control message. The message is then provided to encoder 16 which provide forward error correction coding upon the control message. The encoded

10   symbols are provided to interleaver 18 which reorders the symbols in accordance with a predetermined interleaver format. The interleaved symbols are provided to repetition generator 20 which repeats the reordered symbols to provide additional time diversity in the transmission. The interleaved symbols are provided on line 42 to modulator 26.

15   Variable rate data source 1 generates variable rate data. In the exemplary embodiment, variable rate data source 1 is a variable rate speech encoder such as described in aforementioned U.S. Patent No. 5,414,796. Variable rate speech encoders are popular in wireless communications because their use increases the battery life of wireless communication

20   devices and increases system capacity. The Telecommunications Industry Association has codified the most popular variable rate speech encoders in such standards as Interim Standard IS-96 and Interim Standard IS-733. These variable rate speech encoders encode the speech signal at four possible rates referred to as full rate, half rate, quarter rate or eighth rate according to

25   the level of voice activity. The rate indicates the number of bits used to encode a frame of speech and varies on a frame by frame basis. Full rate uses a predetermined maximum number of bits to encode the frame, half rate uses half the predetermined maximum number of bits to encode the frame, quarter rate uses one quarter the predetermined maximum number

30   of bits to encode the frame and eighth rate uses one eighth the predetermined maximum number of bits to encode the frame.

Variable rate date source 1 provides the encoded speech frame to CRC and tail bit generator 2. CRC and tail bit generator 2 appends a set of cyclic redundancy check bits which are parity bits used to check the accuracy of the

35   decoding at the central base station and appends a predetermined set of tail bits to the control message. The frame is then provided to encoder 16 which provide forward error correction coding on the speech frame. The encoded

symbols are provided to interleaver 6 which reorders the symbols in accordance with a predetermined interleaver format. The interleaved symbols are provided to repetition generator 8 which provided repetition of the reordered symbols to provide additional time diversity in the transmission. The interleaved symbols are provided on line 46 to modulator 26.

In the exemplary embodiment, modulator 26 modulates the data channels in accordance with a code division multiple access modulation format and provides the modulated information to transmitter (TMTR) 28 which amplifies and filters the signal and provides the signal through duplexer 30 for transmission through antenna 32.

FIG. 2 illustrates a functional block diagram of an exemplary embodiment of modulator 26 of FIG. 1. The first supplemental data channel data is provided on line 38 to spreading element 52 which covers the supplemental channel data in accordance with a predetermined spreading sequence. In the exemplary embodiment, spreading element 52 spreads the supplemental channel data with a short Walsh sequence (+--+). The spread data is provided to relative gain element 54 which adjusts the gain of the spread supplemental channel data relative to the energy of the pilot and power control symbols. The gain adjusted supplemental channel data is provided to a first summing input of summer 56. The pilot and power control multiplexed symbols are provided on line 40 to a second summing input of summing element 56.

Control channel data is provided on line 42 to spreading element 58 which covers the supplemental channel data in accordance with a predetermined spreading sequence. In the exemplary embodiment, spreading element 58 spreads the supplemental channel data with a short Walsh sequence (++++----). The spread data is provided to relative gain element 60 which adjusts the gain of the spread control channel data relative to the energy of the pilot and power control symbols. The gain adjusted control data is provided to a third summing input of summer 56.

Summing element 56 sums the gain adjusted control data symbols, the gain adjusted supplemental channel symbols and the time multiplexed pilot and power control symbols and provides the sum to a first input of multiplier 72 and a first input of multiplier 78.

The second supplemental channel is provided on line 44 to spreading element 62 which covers the supplemental channel data in accordance with

a predetermined spreading sequence. In the exemplary embodiment, spreading element **62** spreads the supplemental channel data with a short Walsh sequence (+-+-). The spread data is provided to relative gain element **64** which adjusts the gain of the spread supplemental channel data. The

5    gain adjusted supplemental channel data is provided to a first summing input of summer **66**.

The fundamental channel data is provided on line **46** to spreading element **68** which covers the fundamental channel data in accordance with a predetermined spreading sequence. In the exemplary embodiment,

10   spreading element **68** spreads the supplemental channel data with a short Walsh sequence (++--). The spread data is provided to relative gain element **70** which adjusts the gain of the spread fundamental channel data. The gain adjusted fundamental channel data is provided to a second summing input of summer **66**.

15   Summing element **66** sums the gain adjusted second supplemental channel data symbols and the fundamental channel data symbols and provides the sum to a first input of multiplier **74** and a first input of multiplier **76**.

In the exemplary embodiment, a pseudonoise spreading using two

20   different short PN sequences ($PN_I$ and $PN_Q$) is used to spread the data. In the exemplary embodiment the short PN sequences, $PN_I$ and $PN_Q$, are multiplied by a long PN code to provide additional privacy. The generation of pseudonoise sequences is well known in the art and is described in detail in aforementioned U.S. Patent No. 5,103,459. A long PN sequence is

25   provided to a first input of multipliers **80** and **82**. The short PN sequence $PN_I$ is provided to a second input of multiplier **80** and the short PN sequence $PN_Q$ is provided to a second input of multiplier **82**.

The resulting PN sequence from multiplier **80** is provided to respective second inputs of multipliers **72** and **74**. The resulting PN

30   sequence from multiplier **82** is provided to respective second inputs of multipliers **76** and **78**. The product sequence from multiplier **72** is provided to the summing input of subtractor **84**. The product sequence from multiplier **74** is provided to a first summing input of summer **86**. The product sequence from multiplier **76** is provided to the subtracting input of

35   subtractor **84**. The product sequence from multiplier **78** is provided to a second summing input of summer **86**.

The difference sequence from subtractor 84 is provided to baseband filter 88. Baseband filter 88 performs necessary filtering on the difference sequence and provides the filtered sequence to gain element 92. Gain element 92 adjusts the gain of the signal and provides the gain to

5 upconverter 96. Upconverter 96 upconverts the gain adjusted signal in accordance with a QPSK modulation format and provides the unconverted signal to a first input of summer 100.

The summing sequence from summer 86 is provided to baseband filter 90. Baseband filter 90 performs necessary filtering on difference

10 sequence and provides the filtered sequence to gain element 94. Gain element 94 adjusts the gain of the signal and provides the gain to upconverter 98. Upconverter 98 upconverts the gain adjusted signal in accordance with a QPSK modulation format and provides the upconverted signal to a second input of summer 100. Summer 100 sums the two QPSK

15 modulated signals and provides the result to transmitter 28.

FIG. 3 illustrates four graphs of the average energy transmitted by transmitter 28 over a single frame for full rate 300, half rate 302, quarter rate 304, and eighth rate transmissions 306 and 308, respectively. As can be seen, for the full rate transmission 300, the average energy is equal to some

20 predetermined maximum level, E. For half rate transmission 302, the average energy is equal to half the predetermined maximum level, or $E/2$. Likewise for quarter-rate transmission 304, the average energy is equal to one-quarter of the predetermined maximum level, or $E/4$.

For the eighth-rate transmissions 306 and 308, there are two possible

25 transmit energies. The first transmission 306 uses continuous transmission at one-eighth of the predetermined maximum level, or $E/8$. The second transmission 308 (shown in dashed lines), uses a 50% duty cycle transmission at one-quarter of the predetermined maximum level, or $E/4$. In other words, the present invention provides two separate transmission

30 schemes for the eighth-rate frames: a continuous transmission 306 at $E/8$, and a discontinuous transmission 308 at $E/4$. It should be noted that the discontinuous transmission 308 shown in FIG. 3 is merely exemplary. Other duty cycles and energy values are also contemplated by the present invention. For example, a 25% duty cycle at and energy of $E/2$ may be used

35 in one embodiment. Another embodiment uses a 50% duty cycle with the transmission occurring in the first half of the frame, rather than the second half of the frame as shown in FIG. 3. In yet another embodiment, the

transmission start time is randomized during the frame. However, even in the embodiments that do not randomize the transmission, the frame offset staggering in increments of 1.25 ms that is inherent to cdma2000 will distribute the aggregate interference well over a frame duration.

The amount of energy, timing, and duty cycle chosen are not limiting of the present invention. However, in the embodiment shown in FIG. 3, the transmission occurs during the second half of the frame so that power control can be the most accurate at the end of the frame in case the following frame is at a higher data rate. And hence more critical to control accurately since the higher data rate frames are transmitted at higher power and contain more information. Also in the embodiment of FIG. 1, the interleavers 6 and 18 and repetition generators 8 and 20 format the data such that transmitting only the second half of the frame ensures that each of the original information bits are transmitted at least once.

Control processor 36 controls the selection of whether the eighth-rate transmission is continuous or discontinuous. Variable rate data source 1 generates a rate indication to control processor 36, informing the control processor 36 what the present data rate is. In response, control processor 36 determines whether to gate transmitter 28 on and off to implement the discontinuous transmission of the eighth-rate frames. In one embodiment of the present invention, control processor 36 instructs message generator 12 to generate a message for transmission to the base station over the control channel indicating that the wireless communication device 50 intends to operate in the discontinuous mode. In another embodiment, this message may be a request to operate in discontinuous mode, provided that the base station receiver can support discontinuous mode transmissions.

In one embodiment of the present invention, the control processor 36 may be programmed to always transmit eighth-rate frames according to the discontinuous mode shown as dashed line 308 of FIG. 3. In another embodiment, the control processor 36 may dynamically determine whether to transmit continuously or discontinuously according to the present transmit power of transmitter 28. Since the AM interference caused by discontinuous transmission is proportional to the amplitude of the transmitted signal, the control processor 36 may compare the present transmit power to a predetermined threshold. If the transmit power is greater than the predetermined threshold, the control processor 36 does not gate the transmitter 28, resulting in continuous transmission. If the

transmit power is less than or equal to the predetermined threshold, the control processor **36** does gate the transmitter **28**, resulting in discontinuous transmission. In such an embodiment, the present transmit power may be determined by any means known in the art. For example, by measuring the output power of transmitter **28** with a conventional signal level detector circuit (not shown), or by accumulating power control commands from the base station, or by monitoring automatic gain control signals being sent to the transmitter **28**. Each of these power measurement techniques is well known in the art and will not be expanded upon herein.

In another embodiment of the present invention, the control processor **36** determines whether to transmit continuously or discontinuously according to user-defined preferences. For example, a menu option may be presented to a user on a graphical display (not shown), allowing the user to enable or disable discontinuous transmission. This embodiment would be particularly useful to persons using sensitive electronic equipment such as hearing aids and pacemakers to allow them to program their wireless communication device to always perform continuous transmission. This allows the user to make their own decision about the tradeoff between battery life and potentially dangerous AM interference. Still another embodiment allows discontinuous transmission during voice calls, and disables discontinuous transmission during data calls.

Typical wireless communication device power amplifiers use significant amounts of current. Also, other transmit signal processing components consume power. An example of the current consumption for various components in the transmitter **28** is shown in TABLE I below.

TABLE I

| Function | Current (mA) |
|---|---|
| Power Amplifier Bias Current | 110-130 mA |
| Power Amplifier Driver Current | 42 mA |
| DAC, filtering, upconverter, AGC | 40 mA |
| Total | 202 mA |

As can be seen from TABLE I above, approximately 202 mA of current may be switched out during discontinuous transmission in a typical wireless communication device. A typical variable rate data source **1**, during normal human speech, will produce eighth-rate frames about 63% of the time. So

the potential average current savings for the example of TABLE I is about 63% eighth-rate frames * 50% duty cycle * 202 mA = 64 mA. This is a significant amount of current savings in a typical wireless communication device where the total current consumption is approximately 320 mA at 100% duty cycle. In this example, discontinuous transmission of eighth-rate frames at a 50% duty cycle yields about a 25% increase in talk time.

In addition to the increase in talk time, a system capacity benefit is also realized by the present invention. As is known in the art, the strength of the reverse link pilot signal is driven primarily by the need to track the carrier phase and timing of the reverse link waveform. For most of the time during voice calls a typical wireless communication device is transmitting eighth-rate frames, and therefore is transmitting mostly pilot energy. By turning both the pilot and data signals off during low rate frames, the present invention enhances system capacity.

For example, if we assume that the required traffic component $E_b/N_0$ is 1.6 dB per antenna at 9600 bps, 0.1 dB per antenna at 1500 bps, and the required pilot component $E_c/N_0$ is −22.1 dB per antenna, we find the pilot power fraction shown below in TABLE II.

TABLE II

| Traffic Data Rate (bps) | Traffic $E_b/N_0$ (dB) per antenna | Average Pilot $E_c/N_0$ (dB) per antenna | Pilot Power (%) |
|---|---|---|---|
| 9600 | 1.6 | -22 | 36% |
| Continuous 1500 | 0.1 | -22 | 86% |
| 50% duty cycle 1500 | 0.1 | -25 | 76% |

Using the approximations shown above in TABLE II, gating the 1500 bps frames at the 50% duty cycle reduces the average voice call $E_c/N_0$ by 0.85 dB for 8 kbps vocoder operation.

By operating at the exemplary 50% duty cycle for eighth-rate frames, the ability to maintain power control on the reverse link and forward link is affected. The update rate is reduced by a factor of two. For example, the update rate in a cdma2000 system may be reduced from 800 times per second to 400 times per second. This tends to cause an increase in the frame error rate for the eighth-rate frames. However, the increase in capacity and talk time gained by the present invention may outweigh this decrease in power

control accuracy in many applications. Additionally, in one embodiment of the present invention, the transmit period (i.e., the time that the transmitter **28** is gated "on") is arranged to occur at the end of the frame so that power control is most accurate at the frame boundary where the data rate may
5    suddenly increase for the next frame.

Turning now to FIG. 4, a functional block diagram of selected portions of a base station **400** in accordance with the present invention. Reverse link RF signals from the wireless communication device **50** (FIG. 1) are received by receiver (RCVR) **402**, which downconverts the received reverse link RF
10   signals to an baseband frequency. The baseband signal is then demodulated by demodulator **404**. Demodulator **404** is further described with reference to FIG. 5 below.

In the exemplary embodiment of FIG. 4, demodulator **404** has multiple outputs **405A-405N**, each corresponding to a different one of the
15   logical channels modulated by modulator **26** of FIG. 1. For example, output **405A** corresponds to the control channel **42** of FIG. 1, and output **405N** corresponds to the fundamental channel **46** of FIG. 1. Demodulator **404** typically will have other demodulated signal outputs. However, for clarity and simplicity, only the control channel **405A** and fundamental channel
20   **405N** are shown in FIG. 4.

The control channel **405A** data is de-interleaved by deinterleaver **406**, decoded by decoder **408** and CRC checked by CRC checker **410**. Each of these functional blocks **406-410** performs a complementary function as their counterparts in blocks **14-18** of FIG. 1. The control channel data is then
25   passed to control processor **412** for further processing. For example, the control channel data may include a message from the wireless communication device **50** indicating that it either intends, or is requesting, to operate in discontinuous mode. In response to this message, control processor **412** directs message generator **424** (which includes forward link
30   data formatting) to generate a reply message to the wireless communication device **50**, acknowledging reception of the intention or request message. The acknowledgment message is then modulated by modulator **422** and transmitted by transmitter (TMTR) **420**.

The fundamental channel **405N** is de-interleaved by deinterleaver
35   **414**, decoded by decoder **416** and CRC checked by CRC checker **418**. Each of these functional blocks **414-418** performs a complementary function as their counterpart blocks **2-6** of FIG. 1. The fundamental channel data is then

passed to other subsystems (not shown) in the base station **400** for further processing as required.

When control processor **412** receives a request message from wireless communication device **50** to operate in discontinuous mode, it configures deinterleavers **406, 414**, decoders **408, 416**, and CRC checkers **410, 418** for operation in discontinuous mode. In one embodiment, this means that deinterleavers **406, 414**, decoders **408, 416**, and CRC checkers **410, 418** ignore the portions of the frame that do not contain data.

Turning now to FIG. 5, an expanded functional block diagram of an exemplary single demodulation chain of demodulator **404** is shown. In the preferred embodiment, demodulator **404** has one demodulation chain for each information channel. The exemplary demodulator **404** of FIG. 5 performs complex demodulation on signals modulated by the exemplary modulator **26** of FIG. 1. As previously described, receiver (RCVR) **402** downconverts the received reverse link RF signals to a baseband frequency, producing I and Q baseband signals. Despreaders **502** and **504** respectively despread the I and Q baseband signals using the long code from FIG. 1. Baseband filters (BBF) **506** and **508** respectively filter the I and Q baseband signals.

Despreaders **510** and **512** respectively despread the I and Q signals using the $PN_I$ sequence of FIG. 2. Similarly, despreaders **514** and **516** respectively despread the Q and I signals using the $PN_Q$ sequence of FIG. 2. The outputs of despreaders **510** and **512** are combined in combiner **518**. The output of despreader **516** is subtracted from the output of despreader **512** in combiner **520**.

The respective outputs of combiners **518** and **520** are then Walsh-uncovered in Walsh-uncoverers **522** and **524** with the Walsh code that was used to cover the particular channel of interest in FIG. 2. The respective outputs of the Walsh-uncoverers **522** and **524** are then summed over one Walsh symbol by accumulators **530** and **532**.

The respective outputs of combiners **518** and **520** are also summed over one Walsh symbol by accumulators **526** and **528**. The respective outputs of accumulators **526** and **528** are then applied to pilot filters **534** and **536**. Pilot filters **534** and **536** generate an estimation of the channel conditions by determining the estimated gain and phase of the pilot signal data **40** (see FIG. 1). The output of pilot filter **534** is then complex multiplied by the respective outputs of accumulators **530** and **532** in complex

multipliers **538** and **540**. Similarly, the output of pilot filter **536** is complex multiplied by the respective outputs of accumulators **530** and **532** in complex multipliers **542** and **544**. The output of complex multiplier **542** is then summed with the output of complex multiplier **538** in combiner **546**. The output of complex multiplier **544** is subtracted from the output of complex multiplier **540** in combiner **548**. Finally, the outputs of combiners **546** and **548** are combined in combiner **550** to produce the demodulated signal of interest **405**.

Of particular interest to the present invention are pilot filters **534** and **536**. In order to obtain a more accurate estimate of the pilot phase and gain during reception of discontinuous transmissions, the present invention preferably uses a pilot filter that accounts for the 180-degree phase shift at the boundary between continuous and discontinuous transmission in any frame. For example, in the 50% duty cycle transmission **308** (FIG. 3), the pilot filter account for the phase change that occurs at time T/2 in each frame of length T.

One embodiment of the present invention utilizes a "sliding" filter window in combination with a "blocked" filter window in order to avoid improper pilot estimation at the discontinuity boundary. The "blocked" filter is used to estimate the pilot gain and phase immediately before and after any discontinuities in the frame. The "sliding" filter is used to estimate the pilot gain and phase during the remainder of the frame. An exemplary pilot filter that uses a sliding window estimator **600** in combination with a block window estimator **612** is shown in FIG. 6.

In FIG. 6, the output of either accumulator **526** of **528** is applied to shift register **602**, and is also fed forward to combiner **604**. In the exemplary embodiment, shift register **602** is a twelve-stage shift register. The shifted output of shift register **602** is subtracted from the fed-forward input in combiner **604** and provided to combiner **606**. The output of combiner **606** is delayed in delay element **608** and fed back to be combined with the output of combiner **604** in combiner **606**. The output of delay element **608** is also provided to truncator **610** where it is truncated to be 11 bits, and provided as one selectable input to multiplexer **614**. This input to multiplexer **614** represents the sliding window estimate of the pilot phase and gain.

The output of either accumulator **526** or **528** is also provided to block window estimator **612** which simply accumulates the signal over a predetermined period and provides an output representing the block

window estimate of the pilot phase and gain as a second selectable input to multiplexer **614**.

Multiplexer **614** is controlled by a select signal from control processor **412** which selects between the sliding window estimate and the block window estimate inputs when operating in the discontinuous transmit mode. During a predetermined period immediately before and after any discontinuity, control processor **412** selects the block window estimate from multiplexer **614**. At other times during the frame, control processor **412** selects the sliding window estimate from multiplexer **614**. The output of multiplexer **614** is then applied to either complex multipliers **538** and **540** or **542** and **544** as shown in FIG. 5.

A slightly different embodiment of the pilot filters **534, 536** implements a sliding window equal taps FIR filter of 2.5 ms in length. However, due to the phase discontinuity boundaries caused by discontinuous transmission, the window size is reduced immediately before and after each phase discontinuity boundary to smooth the effect of the phase discontinuity. The filter is updated at the modulation symbol rate which in the exemplary embodiment is one update every two chips. This results in the corresponding phase estimate output also having a two chip resolution. The minimum window size is preferably 1.25 ms, and the window size grows symbol by symbol until it reaches the sliding window buffer size of 2.5 ms. Other embodiments may use combinations of the techniques described above to account for the phase discontinuity boundaries inherent in discontinuous transmission.

FIG. 7 shows the apparatus of the final aspect of present invention. A Code Division Multiple Access (CDMA) mobile station 700 includes a symbol source 702, an interleaver 704, and a transmitter 706. The symbol source 702 may be a conventional microphone and vocoder.

The interleaver 704 is connected to receive symbols from the symbol source 702, and is constructed to interleave them within a frame. The transmitter 706 is connected to receive the frame of interleaved symbols, and is constructed to transmit it.

The apparatus further includes a gate 708 constructed to disable transmission during a fraction F of the frame. The interleaver 704 is constructed to repeat each symbol at least 1/F times. The gate 708 of FIG. 7 is shown as connected directly to the transmitter 706. It could alternatively

fractionally disable transmission by manipulating the interleaver 704. This alternative structure is more complicated and is not preferred.

Preferably, F = 1/2, so the interleaver 704 repeats each symbol at least twice (and preferable more times) in the frame. Thus, even though half of the frame is not transmitted, at least one copy (and preferably more copies) of each symbol is transmitted in each frame.

It is better for the gate 708 to be constructed to disable the transmitter 706 during the first half of the frame rather than the second half. If the transmitted portion of the frame occurs later in the frame, then the mobile station can better estimate the difference between the measured and expected forward signal to noise ratio.

The conventional mobile station 700 includes a frame rate indicator 710, which produces an indication as to how fast the mobile station 700 is transmitting. This indication is useful for many purposes. In the present invention, it is applied to a selector 712. The selector 712 is connected to receive the frame rate indication from the frame rate indicator 710. It is also constructed to selectively enable the gate 708 in response to the frame rate indication. That is, it selectively instructs the gate 708 to turn off the transmitter 706 during the first half of the frame (enables the gate), or instructs the gate 708 to leave the transmitter 706 on for the entire frame (disables the gate).

If desired, the selector 712 may include an adjustment mechanism 714 constructed to enable the gate for all frame rate indications. This is desirable if the mobile station is used in an area where capacity is limited. However, this gating on and off produces interference in the audio band. When it is important to reduce audio interference, the adjustment mechanism 714 may be constructed to disable the gate for all frame rate indications. Preferably, however, the adjustment mechanism 714 is constructed to enable the gate for a first predetermined set of frame rate indications 716, and to disable the gate for a second predetermined set of frame rate indications 718.

The apparatus may also include a mode commander 720, constructed to command a mode in which transmission of frames is enabled only when one of the first (generally slower) predetermined set of frame rate indications is applied to the mode commander 720. That is, the transmitter 706 is disabled -- for the entire frame, and not just for its first half -- for the second (generally faster) set of frame rates. Thus, the transmitter 706 is disabled for the first half of every frame (and also for the second half of some of the frames). This

permits a receiver retuner 722 to be connected to receive a mode command from the mode commander 720. It is constructed to retune a receiver, when so commanded by the mode commander 720, during the fraction of the frame (the first half) during which transmission is disabled.

5      The conventional mobile station 700 includes a power indicator 724, which indicates the power at which the mobile station 700 is transmitting. The present invention uses this by connecting the selector 712 to receive a power indication from the power indicator 724. The selector 712 is then constructed to selectively enable the gate 708 depending on both the frame

10   rate indication and the power indication.

FIG. 8 shows the method of operation 800 of the final aspect of the present invention. The present invention may thus be viewed as a method 800 for operating a Code Division Multiple Access (CDMA) mobile station. The conventional method includes providing a sequence of symbols 802,

15   interleaving each symbol within a frame 804, and transmitting the frame of interleaved symbols 806. To this, the present invention adds disabling transmission during a fraction F of the frame 808. The interleaving 804 thus must include repeating each symbol at least $1/F$ times. As before, preferably F = $1/2$, and preferably the fractional disabling of the frame transmission takes

20   place during the first half of the frame.

The fractional disabling of the frame transmission is selective in response to a frame rate indication 810. The selective fractional disabling 808 may include fractionally disabling the frame transmission at all frame rate indications 812, or may fractionally disable the frame transmission at no

25   frame rate indication 814.

The selective fractional disabling 808 may include fractionally disabling the frame transmission for a first predetermined set of frame rate indications, and excludes fractionally disabling the frame transmission for a second predetermined set of frame rate indications. The method may further

30   include commanding a mode 816 in which transmission of frames is enabled only for the first predetermined set of frame rate indications. In this case, it also includes retuning a receiver 818, when the mode is so commanded, during the fraction of the frame during which transmission is disabled.

The selective fractional disabling may also include fractionally

35   disabling the frame transmission depending on both the frame rate indication 810 and a power indication 820.

Thus, the present invention provides a method and apparatus for transmit gating in a wireless communication system which allows the wireless communication device to operate either in continuous or discontinuous transmit modes.

5        The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty.

10       Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

**I CLAIM:**

# CLAIMS

1.      In a wireless communication device, a method for transmitting
2   frames of information, the method comprising the steps of:
        transmitting said information continuously throughout said frame
4   when in a continuous transmit mode and said frame is of a first data rate of
    a plurality of data rates; and
6       transmitting said information discontinuously in said frame when in
    a discontinuous transmit mode and said frame is of said first data rate.

2.      The method of claim 1 further comprising the step of
2   transmitting said information continuously throughout said frame when
    said frame is of a second data rate of said plurality of data rates.

3.      The method of claim 2 wherein said first data rate corresponds
2   to a first transmit power and said second data rate corresponds to a second
    transmit power, and wherein said first transmit power is less than said
4   second transmit power.

4.      The method of claim 3 further comprising the step of
2   transmitting said frame of said first data rate at said second transmit power
    when in said discontinuous transmit mode.

5.      The method of claim 4 further comprising the step of
2   transmitting said information at a fifty-percent duty cycle during said frame
    when in said discontinuous transmit mode and said frame is of said first
4   data rate.

6.      The method of claim 5 wherein said information is
2   transmitted during a second half of said frame.

7.      The method of claim 2 further comprising the step of selecting
2   between said continuous transmit mode and said discontinuous transmit
    mode in response to a transmit power of said wireless communication
4   device.

8.      The method of claim 7 further comprising the step of selecting
said discontinuous transmit mode when said transmit power is less than a
predetermined threshold.

9.      The method of claim 2 further comprising the step of selecting
between said continuous transmit mode and said discontinuous transmit
mode according to a user-defined preference.

10.     A wireless communication device for transmitting frames of
information, said wireless communication device comprising:
        a variable rate data source for generating said frames of information,
each of said frames of information having one of a plurality of data rates;
        a transmitter for transmitting said information continuously
throughout said frame when in a continuous transmit mode and when said
frame is of a first data rate of said plurality of data rates, and for transmitting
said information discontinuously in said frame when in a discontinuous
transmit mode and when said frame is of said first data rate; and
        a control processor for selecting between said continuous transmit
mode and said discontinuous transmit mode.

11.     The wireless communication device of claim 10 wherein said
transmitter transmits said information continuously throughout said frame
when said frame is of a second data rate of said plurality of data rates.

12.     The wireless communication device of claim 11 wherein said
first data rate corresponds to a first transmit power and said second data rate
corresponds to a second transmit power, and wherein said first transmit
power is less than said second transmit power.

13.     The wireless communication device of claim 12 wherein said
transmitter transmits said frame of said first data rate at said second transmit
power when in said discontinuous transmit mode.

14.     The wireless communication device of claim wherein said
transmitter transmits said information at a fifty-percent duty cycle during
said frame when in said discontinuous transmit mode and said frame is of
said first data rate.

15. The wireless communication device of claim 14 wherein

2   transmitter transmits said information during a second half of said frame.

16. The wireless communication device of claim 11 wherein said

2   control processor selects between said continuous transmit mode and said
    discontinuous transmit mode in response to a transmit power of said

4   transmitter.

17. The wireless communication device of claim 16 wherein said

2   control processor selects said discontinuous transmit mode when said
    transmit power is less than a predetermined threshold.

18. The wireless communication device of claim 11 wherein said

2   control processor selects between said continuous transmit mode and said
    discontinuous transmit mode according to a user-defined preference.

19. In a wireless receiver, a method for receiving a frame of

2   information wherein said information may be continuously present
    throughout said frame or discontinuously present in said frame, said

4   method comprising the steps of:
        filtering said frame of information in a sliding window filter to

6   produce a sliding window phase estimate signal;
        filtering said frame of information in a block window filter to

8   produce a block window phase estimate signal; and
        selecting between said sliding window phase estimate signal and said

10  block window phase estimate signal in response to whether said
    information is continuously present in said frame.

20. The method of claim 19 further comprising the steps of:

2       selecting said sliding window phase estimate signal when said
    information is continuously present in said frame; and

4       selecting said block window phase estimate signal when said
    information is discontinuously present in said frame.

21. The method of claim 20 further comprising the step of selecting
2   said block window phase estimate signal before and after a phase
discontinuity in said frame.

22. A wireless receiver for receiving a frame of information
2   wherein said information may be continuously present throughout said
frame or discontinuously present in said frame, said wireless receiver
4   comprising:
a sliding window phase estimator for filtering said frame of
6   information in a sliding window to produce a sliding window phase
estimate signal;
8   a block window phase estimator for filtering said frame of
information in a block window to produce a block window phase estimate
10  signal; and
a multiplexer for selecting between said sliding window phase
12  estimate signal and said block window phase estimate signal in response to
whether said information is continuously present in said frame.

23. The wireless receiver of claim 22 wherein said multiplexer
2   selects said sliding window phase estimate signal when said information is
continuously present in said frame, and said block window phase estimate
4   signal when said information is discontinuously present in said frame.

24. The wireless receiver of claim 23 wherein said multiplexer
2   selects said block window phase estimate signal before and after a phase
discontinuity in said frame.

25. In a wireless communication system, a method for
2   communicating a frame of information between a wireless communication
device and a wireless base station in a continuous transmit mode and a
4   discontinuous transmit mode, said method comprising the steps of:
transmitting, from said wireless communication device, said
6   information continuously throughout said frame when in said continuous
transmit mode;
8   transmitting, from said wireless communication device, a first
message notifying said wireless base station of an intention to transmit in a
10  discontinuous mode;

transmitting, from said wireless base station, a second message
12 acknowledging said intention to transmit in said discontinuous mode; and

transmitting, from said wireless communication device and in
14 response to said second message, information discontinuously in said frame when in said discontinuous transmit mode.

26.     The method of claim 25 further comprising the steps of:
2      demodulating, in said base station, said frame of information according to a continuous transmit format when said information is
4 continuously present throughout said frame; and

demodulating, in said base station, said frame of information
6 according to a discontinuous transmit format when said information is discontinuously present in said frame.

27.     A wireless communication system for communicating a frame
2 of information in a continuous transmit mode and a discontinuous transmit mode, said wireless communication system comprising:
4      a wireless communication device for transmitting said information continuously throughout said frame when in said continuous transmit
6 mode, and for transmitting a first message notifying a wireless base station of an intention to transmit in a discontinuous mode;
8      said wireless base station transmitting a second message acknowledging said intention to transmit in said discontinuous mode; and
10     said wireless communication device transmitting information discontinuously in said frame when in said discontinuous transmit mode
12 and in response to said second message.

28.     The wireless communication system of claim 27 further
2 comprising:
a demodulator, in said base station, for demodulating said frame of
4 information according to a continuous transmit format when said information is continuously present throughout said frame, and for
6 demodulating said frame of information according to a discontinuous transmit format when said information is discontinuously present in said
8 frame.

29. Apparatus in a Code Division Multiple Access (CDMA) mobile station,

2      the mobile station including:

(a) a symbol source;

4      (b) an interleaver:

(1) connected to receive symbols from the symbol source; and

6      (2) constructed to interleave them within a frame; and

(c) a transmitter:

8      (1) connected to receive the frame of interleaved symbols; and

(2) constructed to transmit it;

10   characterized in that:

(d) the apparatus further includes a gate constructed to disable

12      transmission during a fraction F of the frame; and

(e) the interleaver is constructed to repeat each symbol at least $1/F$ times.

30. The apparatus of Claim 29,

2     further characterized in that:

$F = 1/2$.

31. The apparatus of Claim 30,

2     further characterized in that:

the gate is constructed to disable the transmitter during the first half of

4     the frame.

32. The apparatus of Claim 31, wherein the mobile station further includes a

2     frame rate indicator,

further characterized in that:

4     the apparatus further includes a selector:

(a) connected to receive a frame rate indication from the frame rate

6     indicator; and

(b) constructed to selectively enable the gate in response to the frame rate

8     indication.

33. The apparatus of Claim 32,

2    further characterized in that:

         the selector includes an adjustment mechanism constructed to enable

4    the gate for all frame rate indications.


34. The apparatus of Claim 32,

2    further characterized in that:

         the selector includes an adjustment mechanism constructed to disable

4    the gate for all frame rate indications.


35. The apparatus of Claim 32,

2    further characterized in that:

         the selector includes an adjustment mechanism constructed to enable

4    the gate for a first predetermined set of frame rate indications, and to disable

     the gate for a second predetermined set of frame rate indications.


36. The apparatus of Claim 35,

2    further characterized in that:

         the apparatus further includes:

4    (a) a mode commander constructed to command a mode in which

         transmission of frames is enabled only when one of the first

6        predetermined set of frame rate indications is applied to the mode

         commander; and

8    (b) a receiver retuner which is:

         (1) connected to receive a mode command from the mode

10           commander; and

         (2) constructed to retune a receiver, when so commanded by the

12           mode commander, during the fraction of the frame during which

             transmission is disabled.


37. The apparatus of Claim 32, wherein the mobile station further includes a

2        power indicator,

further characterized in that:

4      the selector is:

       (a) connected to receive a power indication from the power indicator;

6          and

       (b) constructed to selectively enable the gate depending on both:

8          (1) the frame rate indication; and

           (2) the power indication.


38.    A method for operating a Code Division Multiple Access (CDMA)

2      mobile station, the method including:

       (a) providing a sequence of symbols;

4      (b) interleaving each symbol within a frame; and

       (c) transmitting the frame of interleaved symbols;

6  characterized in that:

       (d) the method further includes disabling transmission during a fraction

8          F of the frame; and

       (e) the interleaving includes repeating each symbol at least 1/F times.


39. The method of Claim 38,

2  further characterized in that:

       F = 1/2.


40. The method of Claim 39,

2  further characterized in that:

       the fractional disabling of the frame transmission takes place during the

4  first half of the frame.


41. The method of Claim 40,

2  further characterized in that:

       the fractional disabling of the frame transmission is selective in

4  response to a frame rate indication.

42. The method of Claim 41,

2    further characterized in that:

the selective fractional disabling includes fractionally disabling the frame

4    transmission at all frame rate indications.


43. The method of Claim 41,

2    further characterized in that:

the selective fractional disabling includes fractionally disabling the frame

4    transmission at no frame rate indication.


44. The method of Claim 41,

2    further characterized in that:

the selective fractional disabling includes fractionally disabling the

4    frame transmission for a first predetermined set of frame rate indications,

and excludes fractionally disabling the frame transmission for a second

6    predetermined set of frame rate indications.


45. The method of Claim 44,

2    further characterized in that:

the method further includes:

4        (a) commanding a mode in which transmission of frames is enabled

only for the first predetermined set of frame rate indications; and

6        (b) retuning a receiver, when the mode is so commanded, during the

fraction of the frame during which transmission is disabled.


46. The method of Claim 41,

2    further characterized in that:

the selective fractional disabling includes fractionally disabling the frame

4    transmission depending on both:

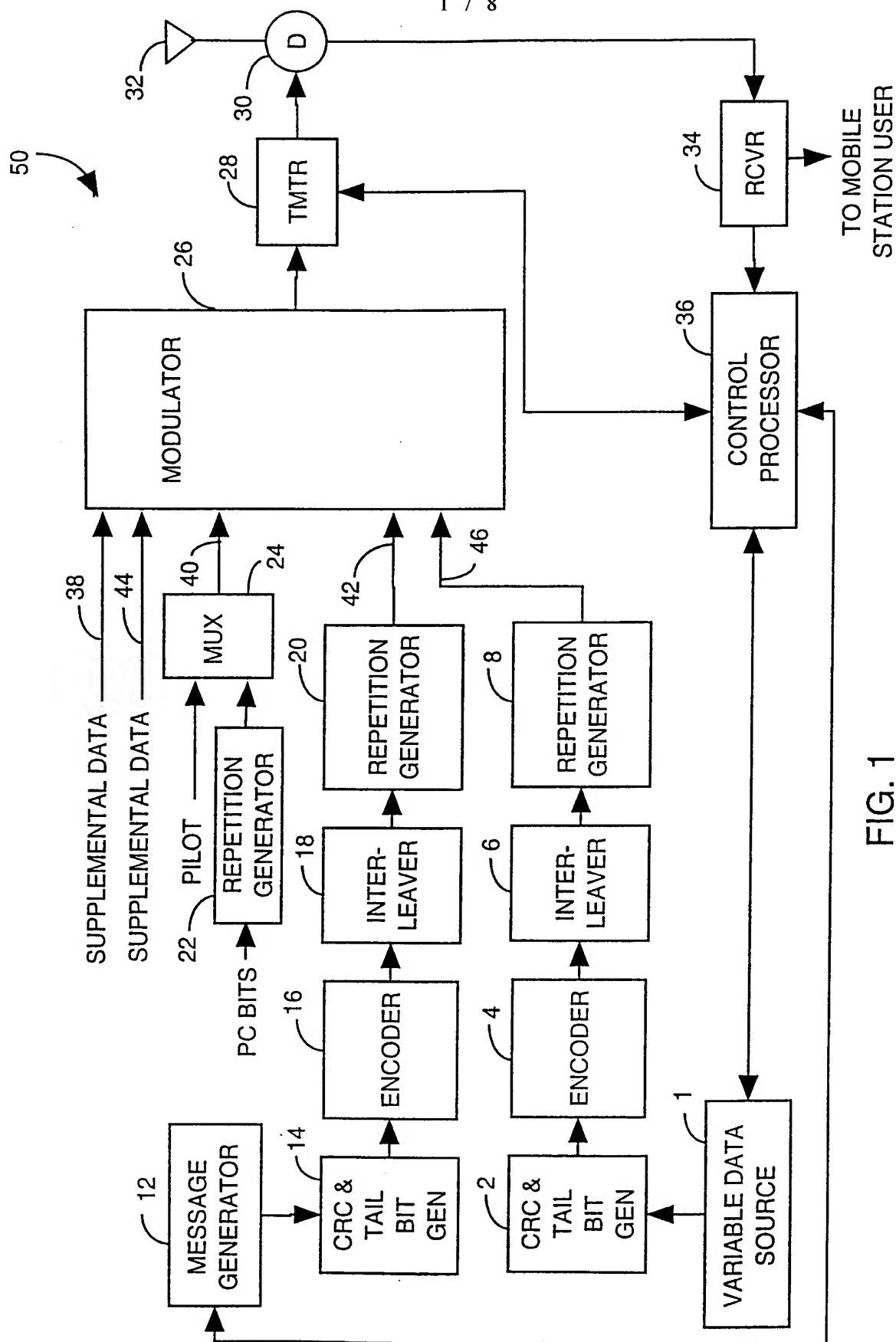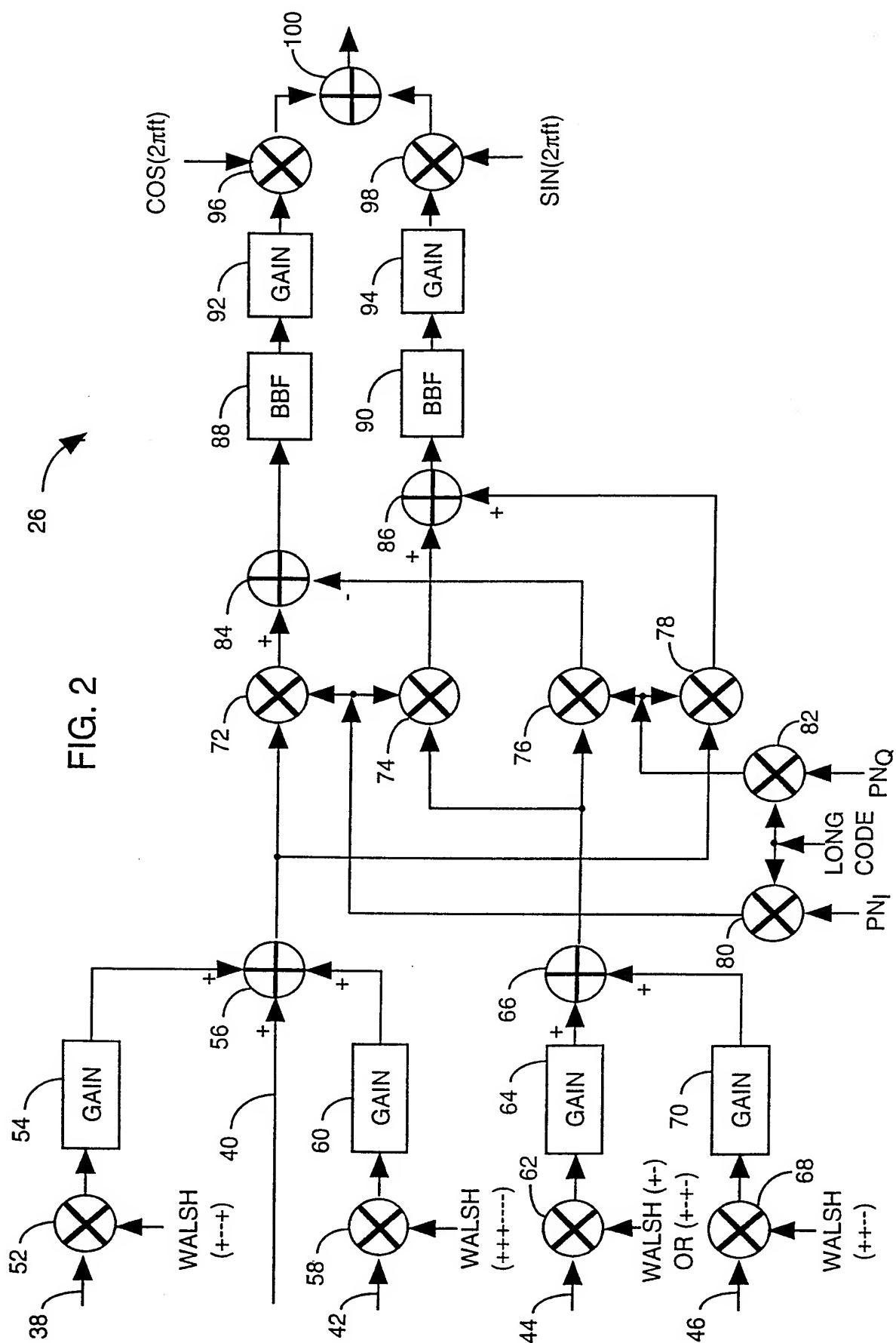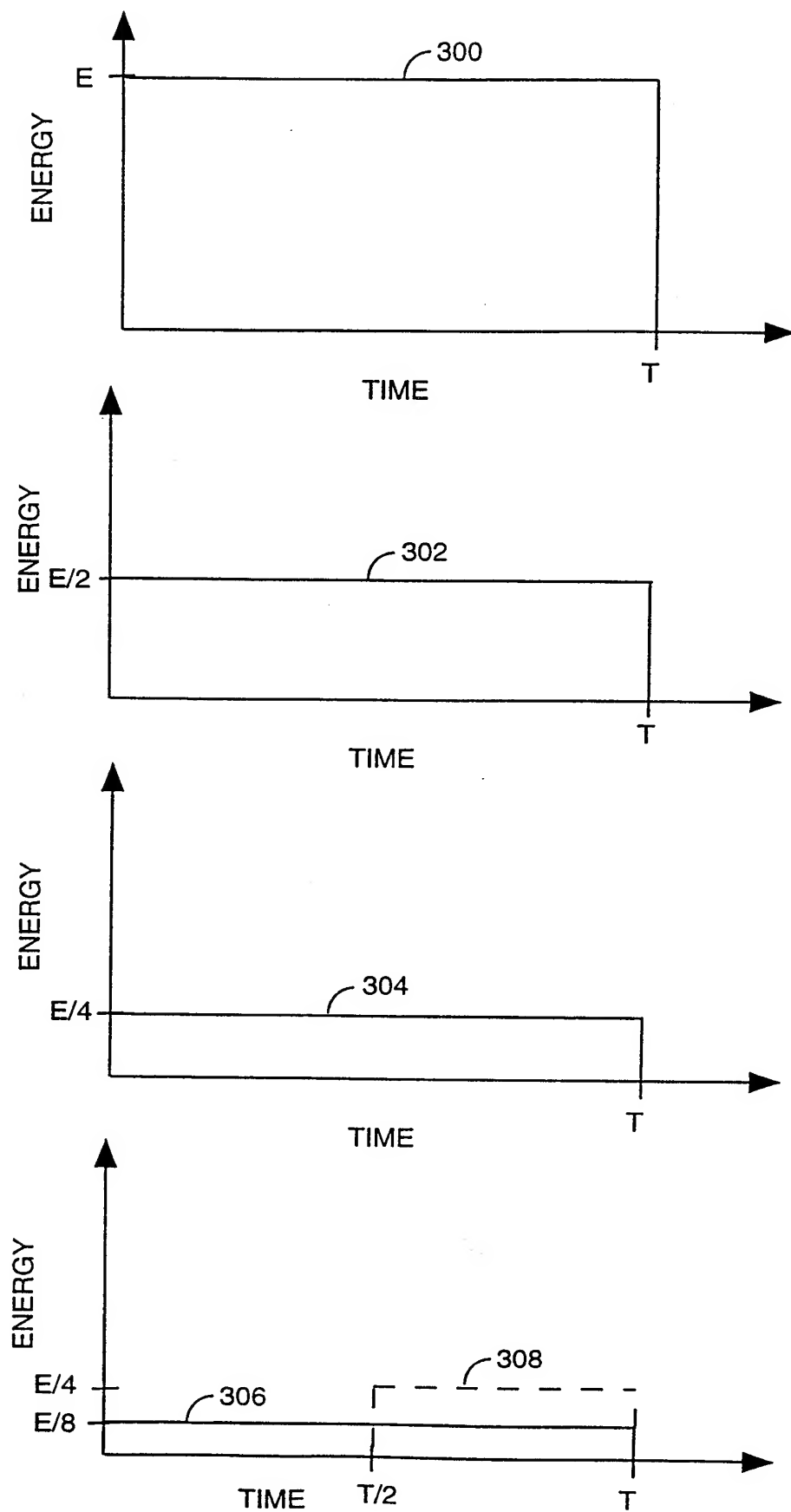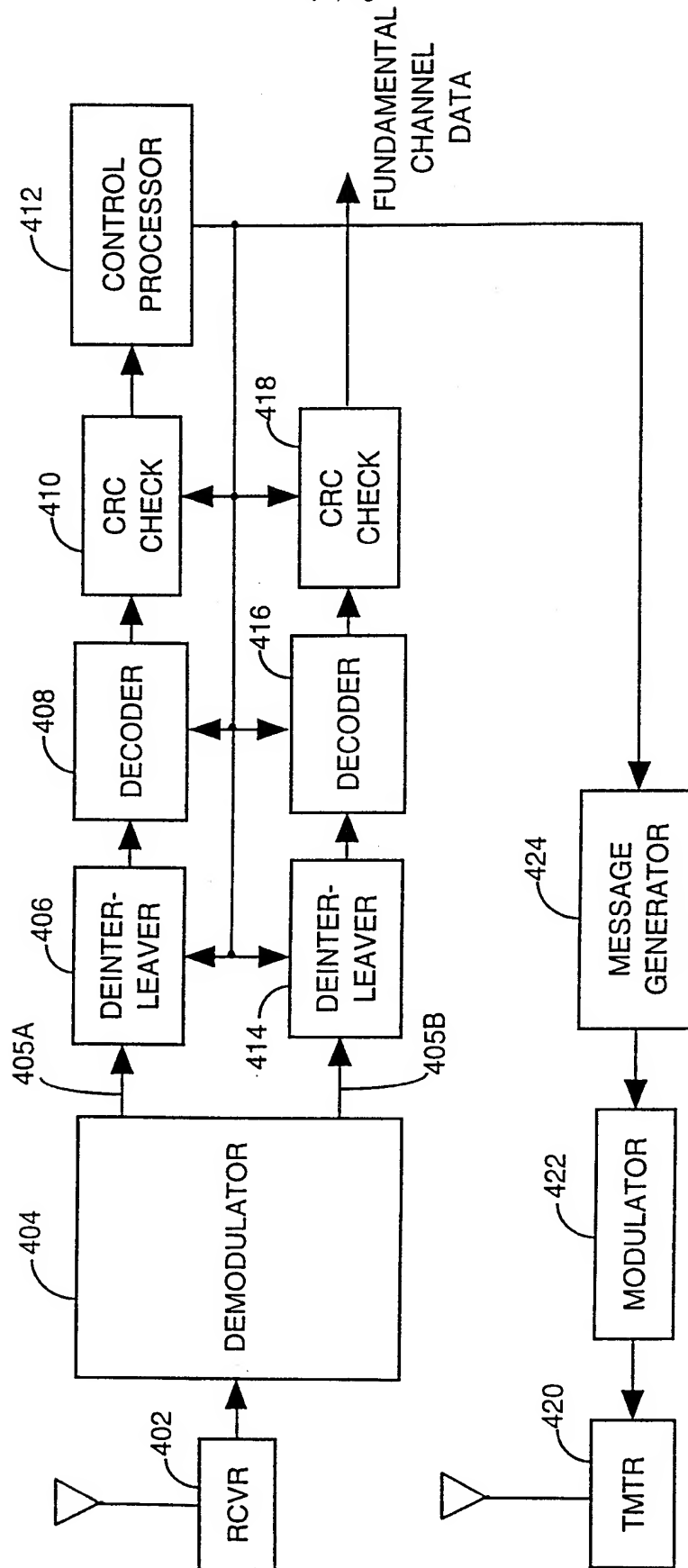(a) the frame rate indication; and

6        (b) a power indication.

FIG. 1

FIG. 2

FIG. 3

FIG. 4
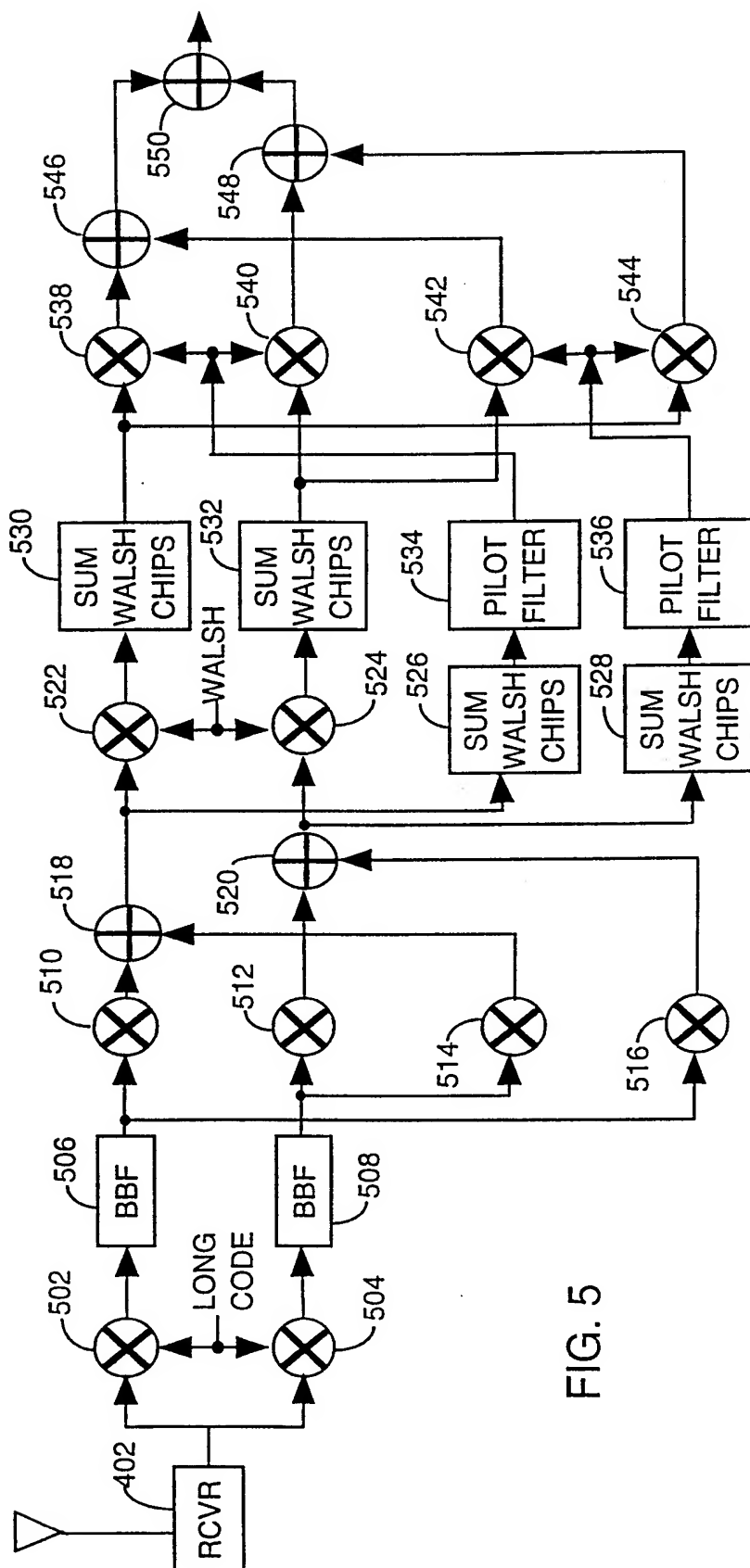
FIG. 5

FIG. 6
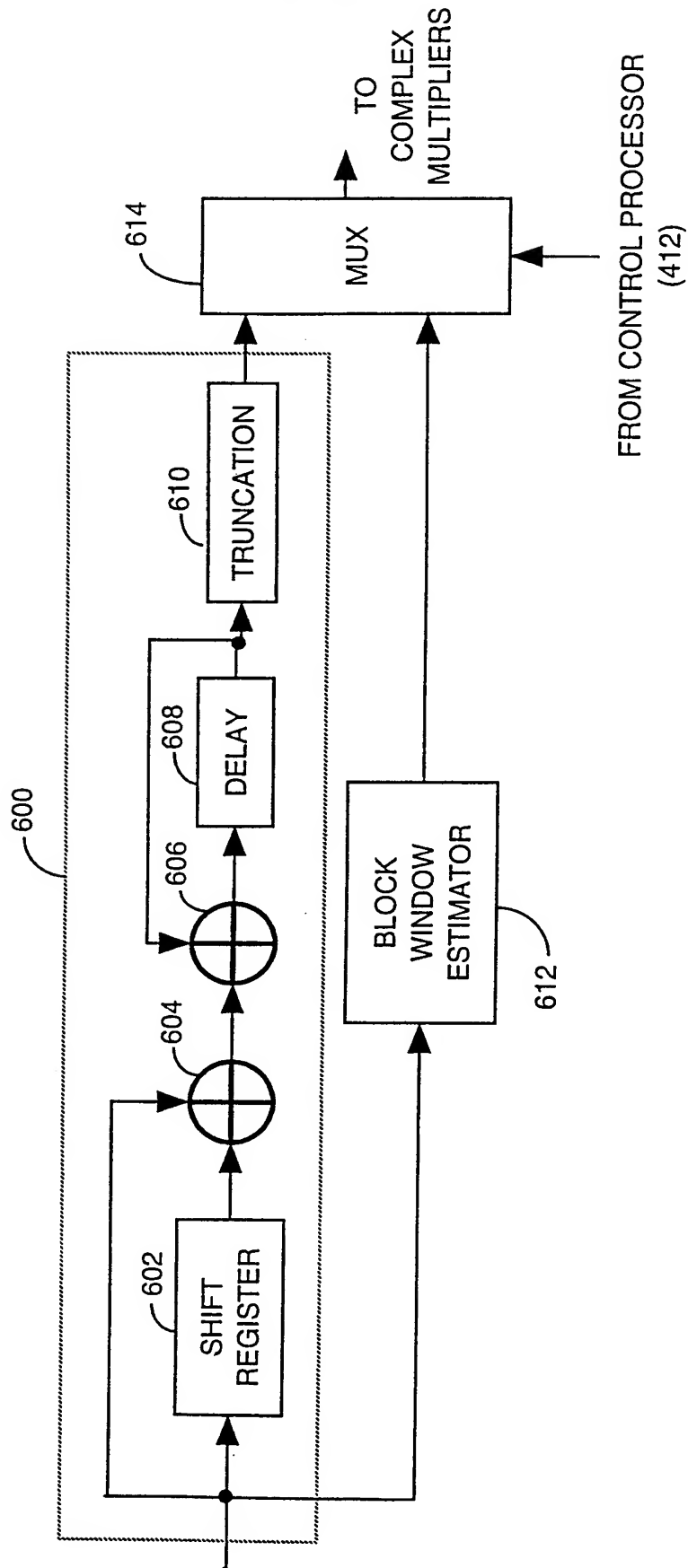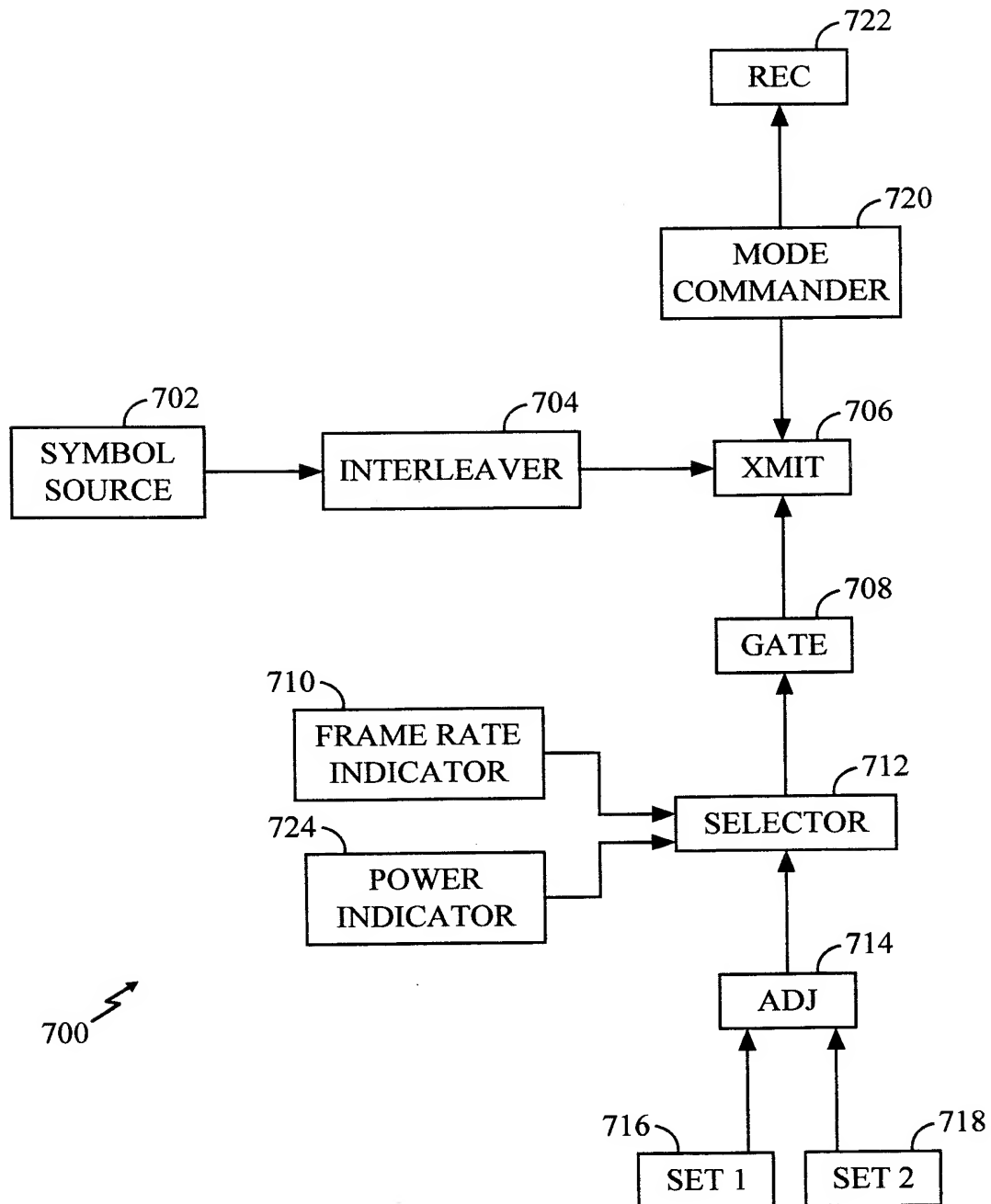
FIG. 7
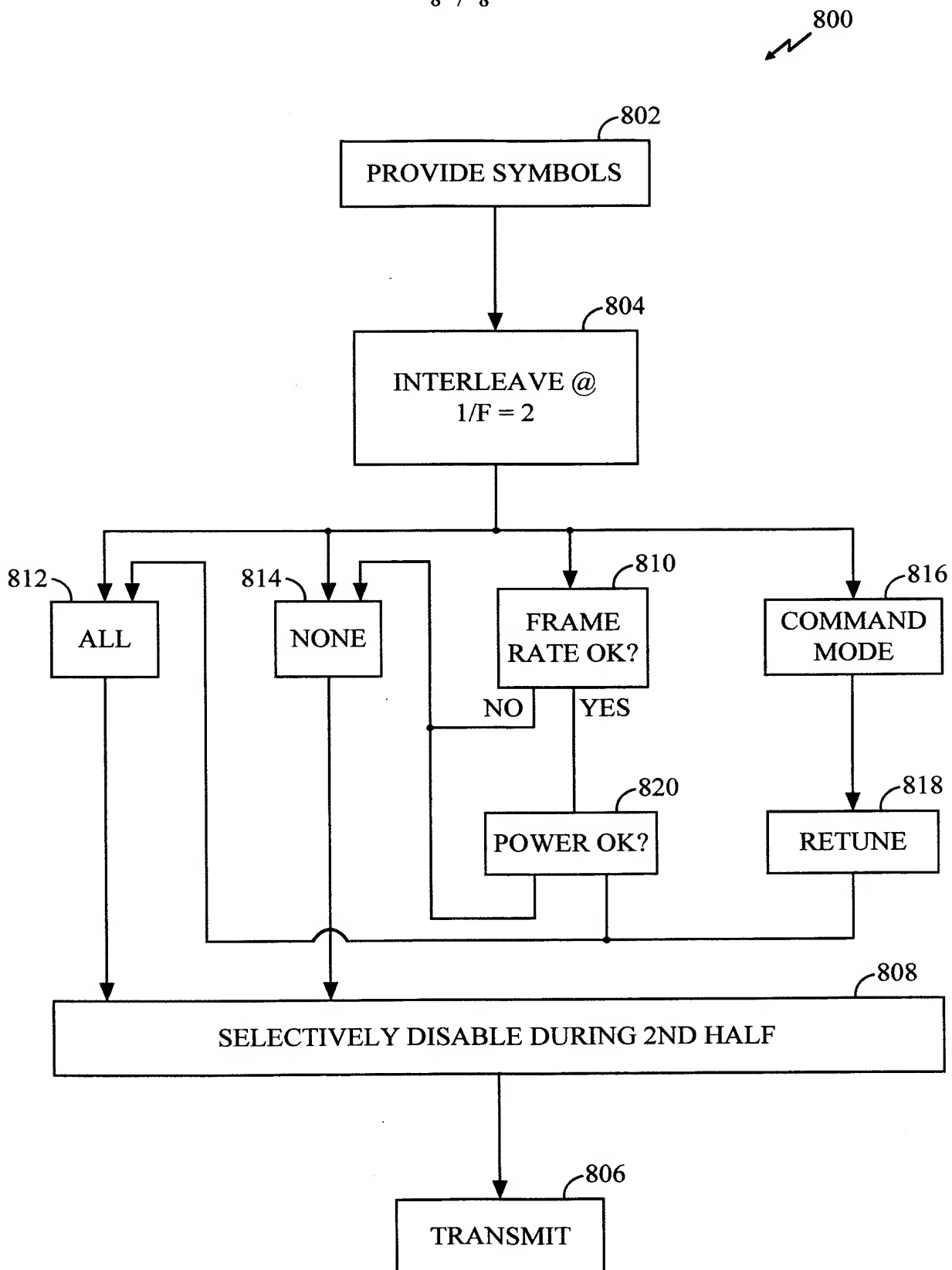
FIG. 8

# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER
IPC 6    H04B7/26        H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6    H04B    H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
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| Date of the actual completion of the international search<br><br>14 June 1999 | Date of mailing of the international search report<br><br>22/06/1999 |
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| Name and mailing address of the ISA<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Authorized officer<br><br>Geoghegan, C |

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